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MATHEMATICAL MODELING OF THE TECHNOLOGICAL PARAMETERS INFLUENCE ON PARAMETERS OF QUALITY OF SAMPLES' SURFACES FROM HARDOX STEEL CUT BY AWJ TECHNOLOGY

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ANNOTATION:
The article presents a demonstration of mathematical models created and verified by set of experiments. Models allow the classification of technological parameters influence of production system with AWJ technology on quality of the cut of the HARDOX 500 steel with thickness 6,10,15,40 mm.
KEYWORDS:
modeling, technological parameter, surface quality, cutting, AWJ, steel

1. INTRODUCTION

AWJ technology belongs to progressive technologies pertaining to jet technology that is used more often for material cutting. Quality of cut surface that is influenced by type of cut material and technological parameters of production system is one of the important aspects that significantly have impact on competitiveness of AWJ technology [1].

Theoretically more supported and objective research of technological and qualitative bindings during activity of production requires the application of theoretically more difficult method from the mathematical modeling field. The article shows mathematical models for quantification of influence the technological parameters of the production system with AWJ technology on quality of the abrasion steel cut created and verified by set of experiments.

2. EXPERIMENTS

Condition of experiments:

Samples for experiments were cut from Swedish steel HARDOX 500, thickness 6, 10, 15, 40 mm.

The influence of three technological parameters (p- pump pressure, v- cutting head speed, m_A- abrasive mass flow) on qualitative roughness parameters of cut surface *Ra*, *Rz* is to be studied. The samples are in a shape of triangle (3 cut surfaces per sample). Each surface of the sample is cut in different combination and in different technological parameter values. The system of marking the samples and their cut surfaces was created for accurate evaluation (to prevent any confusion with samples).

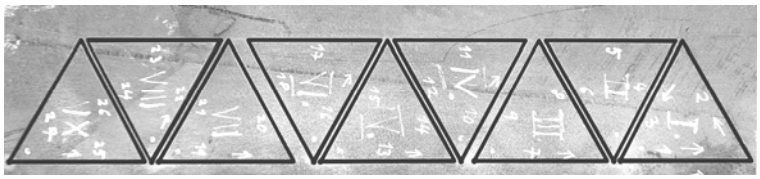

FIGURE 1. Marking and numbering of the samples

Example of sample marking with one chosen cut surface: III/8 indicates the third cut surface from the set of 9 samples. The number "8" indicates the second surface in order that is cut on certain sample and the eighth cut surface from the set of 9 samples with 27 surfaces. The start of cut is indicated by full stop on every upper part of samples' surfaces. An arrow indicates the direction of the cut. The way of marking the samples for evaluation, please see Fig. 1.

3. MODELING THE INFLUENCE OF TECHNOLOGICAL PARAMETERS ON PARAMETERS OF QUALITY

The set of 13 mathematics models is created on the basis of experiments evaluation. The article presents 4 models that allow to quantify two selected combination of technological parameters of

production system with AWJ technology based on parameters of cut surface quality(*Ra*, *Rz*), that completely formulate the roughness of its surface.

The models are valid for HARDOX 500 steel, thickness 10 mm. Models Ra= f (m_A,v)

$$Ra = 5{,}525 - 0{,}012\ m_A + 0{,}011\ v \quad (1)$$

$$Rz = 29{,}923 - 0{,}049\ m_A + 0{,}046\ v \quad (2)$$

m_A is abrasive mass flow, v is the speed of cutting head

Models (1),(2) are valid for pressure cut p=340 MPa. Models Ra = f (m_A,p,v)

$$Ra = 7{,}905 - 0{,}012\ m_A - 0{,}007\ p + 0{,}011\ v \qquad R^2_u = 0{,}872 \quad (3)$$

$$Rz = 39{,}103 - 0{,}049\ m_A - 0{,}027\ p + 0{,}046\ v \qquad R^2_u = 0{,}902 \quad (4)$$

p is pump pressure

4. MODELS TRANSFORMATION INTO THE PROGRAM FILE

Presented mathematics models were transformed into the set of programs in programming language C# because of possibility of using in real time.

5. THE USING OF MODELS FOR SIMULATION

It is possible to use the models for simulation of values of Ra, Rz, depending on changing values m_A, v at constant pressure p or depending on changing values m_A, p at constant speed v.

The independent variables are impossible to fill arbitrarily or randomly. For example, pressures and speeds have their limits in constructional and technological parameters of production system with AWJ and the speeds are also limited by the thickness of cut material.

6. VERIFICATION OF MODELS FOR APPLICATION EXAMPLES

Presented models and program file were verified by application examples by comparing of values Ra, Rz, measured on cut samples during the experiment with theoretical values that were calculated from proper model. The presentation of the verification of models (1), (2) see Table 1 that also contains calculated deviation toward experimental value.

Table 1. Calculated deviation toward experimental value

Number of measu-rement	Technological parameters		Parameters of quality					
	Abrasive mass flow	Speed of cutting	calculated from model		experimentally determined		Deviation of calculated toward experimental values [%]	
	m_A [g/min]	v [mm/min]	Ra (y)	Rz (y)	Ra	Rz	for Ra	for Rz
1	160	35	3,99	23,69	3,81	23,44	4,7	1,1
2	180	38	3,78	22,85	3,60	23,02	5,0	-0,7
3	190	45	3,74	22,68	3,75	22,19	-0,3	2,2
4	200	50	3,68	22,42	3,51	22,06	4,8	1,6
5	210	57	3,63	22,26	3,58	21,77	1,4	2,2
6	230	65	3,48	21,64	3,29	21,28	5,8	1,7
7	250	68	3,27	20,80	3,17	20,31	3,2	2,4
8	260	77	3,25	20,73	3,09	20,03	5,2	3,5
9	280	85	3,10	20,11	2,96	19,09	4,7	5,3

The verification proved the deviation between experimental and calculated values Ra in a range -0.3 to 5.8% and Rz in a range -0.7 to 5.3%, that are acceptable value of deviation.

7. THE USE AND MAIN BENEFITS

The knowledge presented in the article, especially solutions that are partly presented in article have a wider diapason of use in a field of research, in the companies that operate the production systems with AWJ technology and also in pedagogical line.

New original models are the contribution, increasing the quality of cut surface, time shortening for programming and setting up the processor and cutting the operation cost, higher economic effectiveness and competitiveness ability of the companies with AWJ technology [2], and also improving the concreteness and theoretical level of pedagogical process at universities with technological faculties.

8. CONCLUSION

The article presents the demonstration of mathematical models for quantification and simulation of abrasive mass flow influence, the speed of cutting head and pump pressure on parameters of quality of cut surface Ra, Rz, at cutting of steel HARDOX 500, thickness 10 mm by AWJ technology.

The verification of two models in application examples is also presented.

Partial results of dissertation solutions [3], worked out at KPVP FVT TU of Košice with a seat in Prešov (Department of Manufacturing Processes Operation, Faculty of Manufacturing Technologies, Technical University of Košice with a seat in Prešov), are published in the article.

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